NPS-68BF76121

NAVAL POSTGRADUATE SCHOOL

Monterey, California

ATLANTIC WATER ON THE CHUKCHI SHELF

BY

R.H. Bourke and R.G. Paquette

A report submitted to
Director, Arctic Submarine Laboratory
Naval Undersea Center, San Diego,CA

December 1976

NAVAL POSTGRADUATE SCHOOL
Monterey, California

Rear Admiral Isham W. Linder
Superintendent

Jack R. Borsting
Provost

The work reported herein was supported in part by the Arctic Submarine Laboratory, Naval Undersea Center, San Diego, California under Project Order No. 00010.

This report was prepared by:

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NPS-68BF76121	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: ATLANTIC WATER ON THE CHUKCHI SHELF	5. TYPE OF REPORT & PERIOD COVERED: Interim 1 July 1975-30 June 1976
6. PERFORMING ORG. REPORT NUMBER: NPS-68BF76121	
7. AUTHOR(s): Robert H. Bourke and Robert G. Paquette	8. CONTRACT OR GRANT NUMBER(s): P.O. - 00010
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Naval Postgraduate School Monterey, CA 93940	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Element: 62759N Project: F52-555 Task: ZF52-555-01Z Work: 9024909
11. CONTROLLING OFFICE NAME AND ADDRESS: Arctic Submarine Laboratory, Code 90 Bldg. 371, Naval Undersea Center San Diego, CA 92132	12. REPORT DATE: December 1976
	13. NUMBER OF PAGES: 4
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

Published in Geophysical Research Letters, volume 3(10): 629-632, October 1976.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Chukchi Sea
Beaufort Canyon
Arctic Ocean
MIZPAC
Atlantic Water Mass

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

An anomalously warm saline layer in the bottom of the shallow Chukchi Sea in August 1975 is believed due to a surge which drove water from the Atlantic Layer of the Arctic Ocean up onto the shelf. Two earlier occurrences of this kind of water in the Chukchi Sea have been identified in historical data.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE S/N 0102-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

ATLANTIC WATER ON THE CHUKCHI SHELF

R. H. Bourke and R. G. Paquette

Department of Oceanography, Naval Postgraduate School
Monterey, California

stract. An anomalously warm saline layer
e bottom of the shallow Chukchi Sea in
t 1975 is believed due to a surge which
water from the Atlantic Layer of the
c Ocean up onto the shelf. Two earlier
rences of this kind of water in the Chukchi
ave been identified in historical data.

ring the period 2 to 11 August 1975, near
ce margin of the Chukchi Sea, we observed
usual warm layer on the bottom which, to
nowledge, has been recorded only twice be-
by the MAUD in 1922 and by the MIKHAIL
OSOV in 1958. Figure 1 shows where the
water was found (solid circles) and Figure
ws the temperature, salinity and density
les at Station 40, a point at which the
ing is vivid and the warmth of the bottom
is moderate. At this point the tempera-
salinity and sigma-t at the bottom were
°C, 33.15 °/oo and 26.66. In the layer
they were -1.62°C, 32.79 °/oo and 26.40,
ctively. This latter is typical of but
hat less saline than the water we have
on the bottom near the ice in the past
ette and Bourke, 1976).
e inference is that the warm water intruded
neath the bottom water which otherwise
have been resident in the Chukchi Sea.
arm water reached its peak of temperature
alinity at 1.04°C and 33.62 °/oo at the
marked A* in Figure 1. The corresponding
ty was 26.96, a value which sometimes is
ded near and beyond the ice margin but
arily only when accompanied by very low
ratures, colder than -1.6°C. The salini-
and temperatures were highest in general in
asterly of the two patches shown; the low-
emperature and salinity positively identi-
in the warm layer was at -1.28°C and 33.06
in the westerly patch. As the temperature
ases, the anomalous water begins to assume
rties not greatly dissimilar from the nor-
old bottom water, in which case it could
be recognized if it lay under colder wa-
Therefore, the water may have occurred in
other stations.
nceivable sources for the warm water are
llowing:

e warm water had its origin in Bering
t perhaps one or two months earlier and was
ed northward by the usual northerly trans-
of water.
e warm water is a relic of dense water
d in the Chukchi Sea two winters previously
nter overturn; water dense enough to re-
it has not formed during Winter 1974-75
r in the Chukchi Sea or in the Bering Sea,
whichever one considers to be the normal source of bottom water in the Chukchi Sea.

- The water was formed by mixing cold saline bottom water with a warmer water to the south.
- Warm, high-salinity water has surged up onto the Chukchi Shelf from the Arctic Basin and some mixing with water on the shelf has occurred.

In discussing these options, use will be made of the T-S diagram, Figure 3. The anomalous warm water, designated by circles, is called Type A. Attention will be concentrated on the warmest and most saline of these observations, the one previously designated as A*. This water provides the most stringent test of the various hypotheses because it is high temperature coupled with high salinity which is rare in the Chukchi Sea. This group also characterizes bottom water from the six MAUD stations, identified by crosses, which showed bottom water warmer than the overlying water. These stations were located in the north central Chukchi Sea near 72° N between about 171° and 175° W. The triangles denote the bottom water properties from a time series conducted by the MIKHAIL LOMONOSOV near Herald Island at 71-30° N, 176-01° W.

The waters designated B in Figure 3 categorize the most saline and warmer waters which have been found in Bering Strait in the archives of the National Oceanographic Data Center. Area C in the same figure contains perhaps three different kinds of water, all of which are represented in the stations south of the dashed line in Figure 1. This line is the northern limit of stations in which salinities $\geq$ 31 °/oo associated with temperatures $\geq$ 1°C occupy a minimum of 5 m thickness, generally more than 10% of the water column. The most southerly line of stations near Pt. Hope contains in its lower layer, water approximating 1°C and > 32 °/oo, water which Coachman et al. (1976) would call Bering Sea Water. The upper layer in this same line is as warm as 7°C with salinities approximating 31 °/oo. This Coachman et al. would call Alaskan Coastal Water. The line of stations north of Cape Lisburne has the latter water in its lower layer but it has a more dilute warm water in its upper layer which we believe is formed from Alaskan Coastal Water by the addition of fresh water due to ice melt (Paquette and Bourke, 1976). This water reached temperatures greater than 7°C and salinities less than 29 °/oo. This is within the range of properties for the Chukchi Surface Water of Coachman et al. We have put it in the Area labeled D, which is off the diagram. The stations just south of the dashed line have the melt water of Type D in the upper layer, considerable thicknesses of Type C Water in the thermocline and a beginning of the appearance

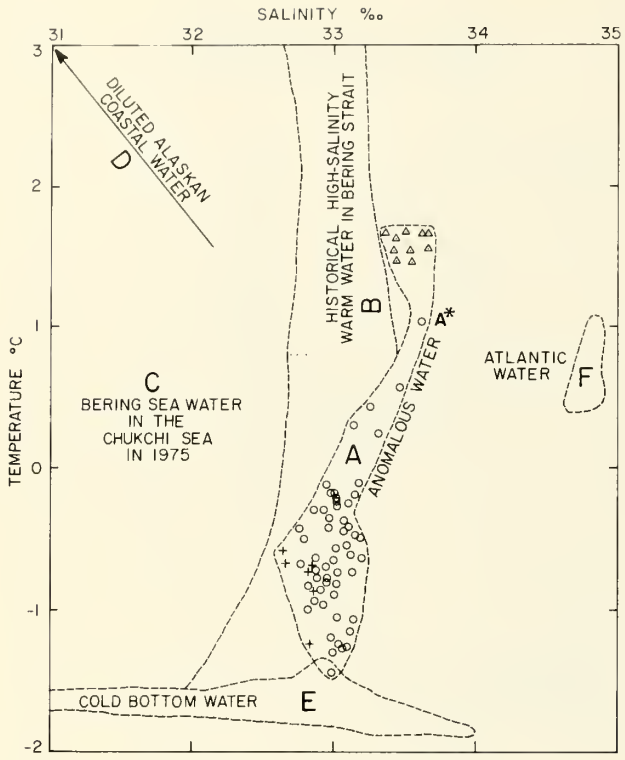

Figure 3. Temperature-salinity diagram showing various water types found in the Chukchi Sea in summer. Open circles are the anomalous warm water, crosses are the MAUD data, and the triangles are from the MIKHAIL LOMONOSOV data.

GLACIER using the University of Washington-A Physics Laboratory (APL) CTD, ably operated Mr. Peter Becker of that laboratory. The da were partially reduced by APL. Others assis were Dr. M. Allan Beal, LT John A. Roeder, US and LCDR William J. Zuberbuhler, USN. LCDR W. Workman kindly searched the historical weather files of Fleet Numerical Weather Cen to provide the Pt. Barrow-Nome pressure differences.

References

Coachman, L. K., K. Aagaard, and R. B. Tripp Bering Strait: The Regional Physical Oce graphy, University of Washington Press, Seattle, WA, 1976.

Mountain, D. B., Bering Sea Water on the Nor Alaskan Shelf, p. 153, Ph.D. Thesis, Univ sity of Washington, Seattle, WA, 1974.

Paquette, R. G., and R. H. Bourke, Observati on the coastal current of Arctic Alaska, Marine Res., 32(2): 195-207, 1974.

Paquette, R. G., and R. H. Bourke, Oceanogra investigations of the marginal sea ice zo of the Chukchi Sea-MIZPAC 1974, Tech. Rep NPS-58PA76051, p. 119, Naval Postgraduate School, Monterey, CA, 1976.

(Received August 10, 1976;
accepted August 27, 1976.)

DISTRIBUTION LIST

ADDRESSEE	NO. OF COPIES
Commander Naval Weapons Center China Lake, California 93555 Attention: Library	1
Commander Naval Electronics Laboratory Center 271 Catalina Boulevard San Diego, California 92152 Attention: Library	1
Director Naval Research Laboratory Washington, D.C. 20375 Attention: Technical Information Division	3
Director Ordnance Research Laboratory Pennsylvania State University State College, Pennsylvania 16801	1
Commander Submarine Force U.S. Atlantic Fleet Norfolk, Virginia 23511	2
Commander Submarine Force U.S. Pacific Fleet N-21 FPO San Francisco, CA 96610	1
Commander Naval Air Development Center Warminster, Pennsylvania 18974	1
Commander Naval Ship Research and Development Center Bethesda, Maryland 20084	1
Chief of Naval Material Department of the Navy Washington, DC 20360	
NMAT 03	2
NMAT 034	1
NMAT 0345	1

DISTRIBUTION LIST

ADDRESSEE	NO. OF COPIES
Director Applied Physics Laboratory University of Washington 1013 Northeast 40th Street Seattle, Washington 98195	
Mr. Robert E. Francois	1
Mr. E. A. Pence	1
Mr. G. R. Garrison	1
Library	1
Director Arctic Submarine Laboratory Code 90, Building 371 Naval Undersea Center San Diego, CA 92132	25
Superintendent Naval Postgraduate School Monterey, California 93940	
Library	2
Dr. R. G. Paquette	5
Dr. R. H. Bourke	5
Polar Research Laboratory, Inc. 123 Santa Barbara Street Santa Barbara, CA 93101	2
Chief of Naval Operations Department of the Navy Washington, DC 20350	
NOP-02	1
NOP-22	1
NOP-946D2	1
NOP-095	1
NOP-098	1
Commander Submarine Squadron THREE Fleet Station Post Office San Diego, CA 92132	1
Commander Submarine Group FIVE Fleet Station Post Office San Diego, CA 92132	1

DISTRIBUTION LIST

ADDRESSEE	NO. OF COPIES
Director Marine Physical Laboratory Scripps Institute of Oceanography San Diego, CA 92132	1
Commanding Officer Naval Intelligence Support Center 4301 Suitland Road Washington, DC 20390	1
Commander Naval Electronic Systems Command Naval Electronics System Command Headquarters Department of the Navy Washington, DC 20360	1
NESC 03	1
PME 124	1
Director Woods Hole Oceanographic Institution Woods HOle, MA 02543	1
Commanding Officer Naval Coastal Systems Laboratory Panama City, FL 32401	1
Commanding Officer Naval Submarine School Box 700, Naval Submarine Base, New London Groton, Connecticut 06340	1
Assistant Secretary of the Navy (Research and Development) Department of the Navy Washington, DC 20350	2
Director of Defense Research and Engineering Office of Assistant Director (Ocean Control) The Pentagon Washington, DC 20301	1
Commander, Naval Sea Systems Command Naval Sea Systems Command Headquarters Department of the Navy Washington, DC 20362	4

DISTRIBUTION LIST

ADDRESSEE	NO. OF COPIES
Chief of Naval Research Department of the Navy 800 North Quincy Street Arlington, VA 22217	1
Code 102-OS	1
Code 220	1
Code 461	1
Project Manager Anti-Submarine Warfare Systems Project Office (PM4) Department of the Navy Washington, DC 20360	1
Commanding Officer Naval Underwater Systems Center Newport, RI 02840	1
Commander Naval Air Systems Command Headquarters Department of the Navy Washington, DC 20361	2
Commander Naval Oceanographic Office Washington, DC 20373	
Attention: Library	2
Director Defense Supply Agency Defense Documentation Center Cameron Station Alexandria, VA 22314	12
Director Advanced Research Project Agency 1400 Wilson Boulevard Arlington, VA 22209	1
Commander SECOND Fleet Fleet Post Office New York, NY 09501	1
Commander THIRD Fleet Fleet Post Office San Francisco, CA 96601	1

DISTRIBUTION LIST

ADDRESSEE	NO. OF COPIES
Commander Naval Surface Weapons Center White Oak Silver Spring, MD 20910	
Mr. M. M. Kleinerman	1
Library	1
Officer-in-Charge New London Laboratory Naval Underwater Systems Center New London, Connecticut 06320	1
Commander Submarine Development Group TWO Box 70 Naval Submarine Base New London Groton, Connecticut 06340	1
Oceanographer of the Navy Hoffman II 200 Stovall Street Alexandria, VA 22332	1
Commandant U.S. Coast Guard Headquarters 400 Seventh Street, SW Washington, DC 20590	2
Commander Pacific Area, U.S. Coast Guard 630 Sansome Street San Francisco, CA 94126	1
Commander Atlantic Area, U.S. Coast Guard Governors Island New York, NY 10004	1